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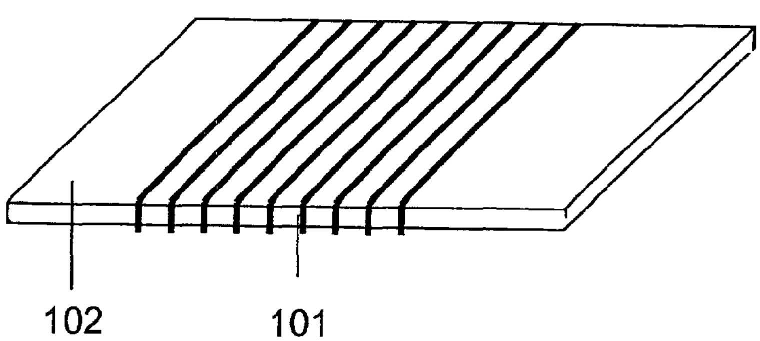

(57) Abstract: There is disclosed a magnetic core component for receiving electrical power by induction. The core component includes a thin sheet of amorphous magnetic material in a substantially amorphous or non-annealed state. In contrast to known core components, which use annealed amorphous magnetic materials, the non-annealed material of the present invention is flexible and non-brittle. This means that it has significant advantages including resistance to physical shocks. This is of importance when the core component is used in portable electronic devices such as mobile telephones and the like which may be subject to physical shocks, for example by being accidentally dropped.

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IMPROVEMENTS RELATING TO THE TRANSFER OF ELECTROMAGNETIC POWER

The present application claims priority from UK patent applications nos 0210886.8 of 13th May 2002, 0213024.3 of 7th June 2002, 0225006.6 of 28th October 2002 and 0228425.5 of 6th December 2002, as well as from US patent application no 10/326,571 of 20th December 2002. The full contents of all of these prior patent applications is hereby incorporated into the present application by reference.

This invention relates to a new apparatus for transferring electromagnetic power, particularly in relation to the powering of portable devices.

In a conventional electrical transformer, an input alternating current flows through a primary coil, inducing an alternating magnetic flux within the transformer core. This alternating magnetic flux then induces an alternating current in a secondary coil.

In certain designs of transformer, for example U-U, U-I, E-I or E-E cores, there may be an air-gap between the two halves of the transformer (see Figure 1). Therefore it is possible to separate the transformer into two: a primary side and a secondary side. When brought together in the correct relative position, the alternating magnetic field in the primary side couples to the core in the secondary side, recreating a transformer and hence power is transferred inductively from the primary side to the secondary side without the need for direct electrical contacts.

Referring to Figure 2, if the primary part is contained within a base unit, and the secondary part within a portable device, then the transformer created when the portable device is placed onto the base unit can be used to provide power to the device without direct electrical contacts, for example to recharge a battery in the secondary device.

Those skilled in the art will recognize that this kind of "separable two-part" transformer system may be implemented with a variety of different core designs and

magnetic field shapes. An alternative, for example, is the simple "axial" design shown in Figure 3. This has poorer field coupling because the magnetic flux must return through the air, but has the advantage of being freely rotatable about its axis.

As portable devices become smaller and thinner - particularly consumer devices in which aesthetic qualities are particularly important - the penalties in volume and weight of such cores makes them undesirable. Bulkiness is one of the reasons why inductive charging has not been widely used in these applications. It is therefore highly desirable to find an alternative magnetic core material for these applications which is not bulky, has as little weight as possible, is not brittle and hence can be made into a laminar (including curved) or substantially flat or planar form-factor while being able to survive drop-tests.

Existing cores are typically made of silicon steel, ferrite or permalloy, materials which are used because of their low cost and high saturation magnetic flux density but which have the following disadvantages:

- Steel (even silicon steel) suffers high loss at higher frequencies (>10kHz) because of low resistivity and hence the generation of eddy currents, and has low permeability. The losses are less severe at low frequencies but the core needs to be larger and more bulky
- Ferrite has high permeability and is low-loss, but is brittle
- Permalloy has a permeability which drops sharply at 10's of kHz.

The above disadvantages make these materials inappropriate for use in thin cores for thin devices: the low permeability of steel and permalloy means that in a flat "form factor" they have insufficient overall permeability, and the brittleness of ferrite means that in a flat form factor it would be unacceptably brittle, failing drop tests.

A possible alternative core material is so-called "amorphous metal". Amorphous metal is a metal alloy, consisting for example of iron, boron and silicon, which has been melted and then cooled so rapidly ("quenched") that there is no time for it to crystallise as it solidifies, leaving it instead in a glass-like amorphous state. A more

detailed description of amorphous metals may be found in US 4,877,464, the full disclosure of which is hereby incorporated into the present application by reference.

A two-stage manufacturing process is used to make (prior art) amorphous metal magnetic cores.

STEP 1 : A typical Production method for amorphous metal tape

The alloy is melted, poured onto a rotating drum and rapidly quenched. The metal emerges in the form of a very thin ribbon, typically 16-25um thick. The resulting amorphous metal tape is magnetically "soft", has high permeability, has a moderate saturation magnetic flux density and is flexible.

STEP 2 : Typical Manufacturing method of conventional bulk magnetic cores from amorphous metal tape

To create a conventional bulk magnetic core (for example: U core, toroidal core) for a transformer or motor, many strips of such amorphous metal tape are then laminated (stacked or wound), usually alternated with insulating adhesive, into the shape of the desired core. The core is then annealed (the temperature is raised and then lowered in a controlled fashion), usually in the presence of a magnetic field. The annealing allows controlled nano-crystallisation of the metal, improving the saturation magnetic flux density. However a negative side-effect of nano-crystallisation is that it increases the atomic order of the material, making it very brittle. In a bulky adhesive-bound core this is often not a problem because any stress is spread throughout the volume of the core.

However this brittleness makes the above "Step 2" core-manufacturing process unsuitable for the production of thin magnetic cores. Throughout the present application, the word "thin" is to be taken to describe a shape substantially smaller in one dimension than in either of its other two dimensions, for example to describe a

shape whose thickness is substantially less than (e.g. less than 1/5 or preferably less than 1/10 of) both its width and length, for example a section of tape.

In most applications of amorphous material as magnetic cores in transformers, this two-step process of first creating an amorphous ribbon, then turning it into a bulk core is highly undesirable because it requires intermediate manufacturing steps, and so research has been conducted to identify ways to achieve the same with a one-stage bulk amorphous alloy production process so that the need first to create thin ribbons is eliminated.

In a thin laminar magnetic core, any shear stress (force applied perpendicular to the plane of the material) is naturally concentrated across a very small cross-section. Any attempt to make a thin magnetic core using the above "Step 2" core-manufacturing stage would result in a very brittle object which is hard to work with in subsequent manufacturing steps, and therefore expensive. Further, such a core would be unsuitable for use in, for example, portable devices which are exposed to very high g forces when dropped.

According to a first aspect of the present invention there is provided a magnetic core component for transferring power by induction to or from a device, the magnetic core component including a thin sheet of metal in a substantially amorphous or non-annealed state and being provided with means for transferring induced electrical power from the core component to a device.

According to a second aspect of the present invention, there is provided a device provided with a magnetic core component for receiving or transmitting power by electromagnetic induction, characterised in that the magnetic core component includes a thin sheet of metal in a substantially amorphous or non-annealed state.

The device will generally be an electronic or electrical device, usually containing a rechargeable cell or battery. Alternatively or in addition, the device itself may be a rechargeable cell or battery.

The amorphous metal is preferably at least 70% amorphous or non-annealed, and even more preferably at least 90% amorphous or non-annealed.

In preferred embodiments, the metal is what is generally known in the art as an "amorphous metal" or alternatively a "metallic glass".

The means for transferring induced electrical power to the device may comprise an electrical conductor wound around or otherwise associated with the thin sheet of amorphous metal and having first and second terminals for connection to power inputs of the device.

The device will generally be a portable device, although non-portable devices may also be provided with a magnetic core component as herein described.

Embodiments of the first aspect of the present invention may be adapted for retro-fitting to an existing device, for example being in the form of a thin patch or sticker suitable for mounting (e.g. by way of adhesion) onto an appropriate internal or external surface of the device and having means for connection to a power input of the device.

The amorphous magnetic core component of embodiments of the present invention has several advantages for use in portable devices, compared with using conventional magnetic cores:

1. It is thin, preferably 0.5mm or even 0.1mm or less, allowing devices into which it is incorporated to be ergonomic, and/or allowing more space for other functionality within such devices
2. It is flexible, therefore:
    a. it is not brittle, despite its thinness, and so:
        i. it is suitable for use in portable devices which may be subject to physical shock.
        ii. it is easy to handle in subsequent manufacturing steps

b. it can easily be flexed into non-flat shapes, possibly to be conformal with the contours of a portable device such as a mobile phone or a wireless headset.

c. it can be a component within a device which is itself flexible (for example a watch strap or an intelligent credit-card), particularly devices which have to flex as part of their operation – for example battery cells tend to bulge somewhat when they are recharged.

3. Because the field travels along the thin core, if the core is placed within a device which is itself thin relative to its length (for example a cell, headset boom or pen), the device can be rotated freely around its axis within an axial magnetic field.

Also of potential benefit, compared to a conventional core, is that very little tooling is required to manufacture the core of embodiments of the present invention.

An example of the material for manufacturing the core is Metglas® 2714A as manufactured by Honeywell. This is a cobalt-based amorphous metal with an ultra-high permeability of >80,000 at DC in the as-cast state, supplied as ribbon on reels.

In use, the core will typically couple to external electromagnetic field lines running in the same plane as the material. Because of its relatively high permeability, it will concentrate nearby lines into it, so will even "capture" field lines running past it. This is shown in Figure 5.

The core will saturate when subjected to a magnetic field above a certain threshold, placing an upper limit on the operational power of the system. Therefore the core must have a sufficiently large cross-section to ensure that saturation does not occur at the desired operational power level. Saturation offers some protection from exposure to very strong magnetic fields, as in this situation the core will saturate, limiting the power transferred to the device.

The core may be located within or near a device which itself contains parallel planes of metal, for example a copper printed circuit board or an aluminium cover. In this case, the performance of the present invention is significantly better than that of a conventional core because the field lines through a conventional coil will suffer flux-exclusion if the coil is placed up against the metal plane (because the lines of flux must travel perpendicular to the plane of the core). Since in the present invention the lines of flux travel along the plane of the core, and therefore of the metal plane, performance is improved. See Figure 6. An additional benefit of embodiments of the present invention compared to a conventional coil is that the core in the present invention may act as a shield for items (e.g. electrical circuits, battery cells) in close proximity to the magnetic core.

Because its permeability is higher than that of air, the core of the present invention acts to concentrate magnetic flux, thus capturing more flux than would otherwise flow through an equivalent cross-section of air. The size of the core's "shape factor" (the equivalent flux-capturing sphere) is determined to a first-order approximation by the longest planar dimension of the core. Therefore if the core of the present invention has planar dimensions with a significantly non-square aspect ratio, for example a 4:1 rectangle instead of a 1:1 square, it will capture proportionally more of any flux travelling parallel to the direction of its longest planar dimension. Therefore if used in devices which have a constrained aspect ratio (for example a long thin device such as a headset or pen), a significant increase in performance will be experienced compared with that of a conventional coil of the same area.

The core may comprise more than one sheet of amorphous metal, the sheets being arranged in parallel with one another (laminated). The sheets may be made of the same amorphous metal material, or of two or more different amorphous metal materials.

The core may be wrapped, encircled, wound or otherwise provided with a coil of conductive wire or tape or a flexible printed circuit. This is preferably wrapped or wound around a smallest of the planar dimensions of the sheet of amorphous metal .

The coil may be tuned to a higher "Q" (quality factor) with a capacitor, in parallel or series, resulting in higher amounts of energy being induced by an external magnetic field, but also in higher dissipation in the module and the need for tuning to a precise driving frequency. The capacitor may be made from multiple layers of amorphous metal in the core, interposed with a dielectric material such as polythene or the like.

The coil may be connected to a half- or full-wave rectifier to convert AC into DC, and may also be connected to an optional smoothing capacitor, an optional regulator or a battery charge-controller.

The core may be provided with a flexible printed coil arranged such that the amorphous core passes through the coil but in the same plane. Alternatively, the magnetic core component may comprise at least two pieces of amorphous sheet or ribbon laminated to each other with a coil located between the sheets or ribbons (see Figure 9).

The core component may be formed from a substantially triangular sheet of amorphous metal which is folded in a concertina-like manner so as to form an elongate ribbon that is thicker in a middle part thereof than at its ends (see Figure 10). Alternatively, a similar structure may be formed by laminating successively shorter strips of ribbon or the like on top of each other, each strip being generally centred about a predetermined point. These structures have the advantage that there is more amorphous metal at a thicker central part of the structure, where there is most flux during operation, than at its thinner ends, where there is less flux. In this way, saturation can be avoided at the central part of the structure while reducing the amount of amorphous material required at the end portions.

The core may be wrapped or wound with first and second coils, the second coil being substantially orthogonal to the first coil, so that power may be captured regardless of a direction of an external field within the plane of the sheet or sheets forming the core (no need for external field to rotate).

The core may be incorporated on or within a portable device which receives and/or transmits power using the core. The following non-exhaustive list illustrates some examples of such devices, possibilities are not limited to those described below:

a. Mobile communication device, for example a radio, mobile telephone or walkie-talkie;
b. Portable computing device, for example a personal digital assistant or palmtop or laptop computer;
c. Portable entertainment devices, for example a music player, games console or toy;
d. Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
e. A portable imaging device, for example a video camcorder or a camera;
f. Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
g. Consumer devices, for example torches, clocks and fans;
h. Power tools, for example cordless drills and screwdrivers;
i. Wireless peripheral devices, for example wireless computer mouse, keyboard and headset;
j. Time keeping devices, for example clock, wrist watch, stop watch and alarm clock;
k. Battery-pack for insertion into any of the above;
l. Standard-sized battery cell.

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made by way of example to the accompanying drawings, in which:

FIGURE 1 shows a prior-art U-U core transformer;

FIGURE 2 shows how two cores of the type shown in Figure 1 may be incorporated

into an electronic device;

FIGURE 3 shows a prior art configuration similar to that of Figure 1, but using an axial core with air as the return path;

FIGURES 4a and 4b show a simple core component of an embodiment of the present invention;

FIGURES 5a to 5c show how the core component of Figures 4a and 4b interacts with an external magnetic field;

FIGURE 6a shows a prior art core component in an electronic device including a metal plane;

FIGURE 6b shows a core component of an embodiment of the present invention in the electronic device of Figure 6a;

FIGURE 7 shows a wireless headset device provided with a core of an embodiment of the present invention;

FIGURE 8 shows an embodiment of the present invention including a coil;

FIGURE 9 shows an embodiment of the present invention comprising two sheets of amorphous metal laminated about a printed coil;

FIGURES 10a to 10e illustrate a method of manufacturing an embodiment of the present invention;

FIGURES 11a to 11c show three different embodiments of the present invention incorporated into a rechargeable battery or cell;

FIGURE 12 shows the battery or cell of Figure 11 located near an external inductive

charging unit; and

FIGURE 13 is a circuit diagram illustrating an embodiment of the present invention.

FIGURE 1 shows a prior-art U-U core transformer showing primary coil 112 through which an alternating current induces an alternating magnetic field in primary core 111. This field then flows between the end-pieces of core 111 and the end-pieces of secondary core 102 through the space therebetween. The field 1 flowing in 102 then induces a current in secondary coil 101.

FIGURE 2 shows how the two cores 111 and 102 of Figure 1 may be incorporated into a prior art electronic device 120 and a charger 130 such that the device 120 may be brought into proximity of the charger 130 to complete a magnetic circuit and transfer power from the charger 130 to the device 120.

FIGURE 3 shows a prior art configuration similar to Figure 1, but using axial cores 102, 111 with air as the return path.

FIGURE 4a shows a laminar sheet of amorphous, non-annealed metal 102 forming a magnetic core component of the present invention coupling to an external magnetic field 1.

FIGURE 4b shows the core component 102 of Figure 4a incorporated within a portable electronic device 120. In the illustrated embodiment, the core 102 is placed on a bottom side of the device 120.

FIGURE 5a shows the device 120 of Figure 4b in plan view and FIGURE 5b shows the device 120 in side view. It can be seen how the high permeability of the core 102 pulls the electromagnetic field 1 into the core 102. Because of this, a field running predominantly under the device 120, shown most clearly in Figure 5b, will be pulled into the device 120, thus coupling effectively to it. FIGURE 5c shows more detailed field lines when two such cores 102 are placed onto a surface which generates a

distributed horizontal field. Note how the field lines travel not only into the ends of the cores, but also into the side surfaces.

FIGURES 6a and 6b show a device 120 which, for reasons unrelated to the present invention, includes a metal plane 125. The flow of flux 1 vertically into a conventional core 108 (Figure 6a) must go through the metal plane 125 and therefore the core 108 suffers from flux exclusion. With a core 102 designed according to embodiments of the present invention (Figure 6b), the flux 1 flows horizontally, alongside the metal plane 125 and through the core 102 with no flux exclusion.

FIGURE 7 shows a portable electronic device 120 in the form of a wireless headset. For ergonomic and aesthetic reasons it is important that this encloses its electronics within a case which is as small and light as possible while conforming to a shape of a human face or head. This makes it a complex curved three-dimensional shape. The laminar amorphous metal core 102 of embodiments of the present invention is able to be bent somewhat to conform to the shape of the headset 120, allowing it to extend for a substantial part of the length of the headset 120, and thus couple very effectively with an external field (not shown).

FIGURE 8 shows a possible arrangement of an electrically-conductive coil 101 spirally wound around a laminar amorphous metal core 102. It is to be noted that the coil 101 is wound about a shorter dimension of the core 102, since most flux will be captured when travelling along the longest planar dimension of the core 102 and therefore more current will be induced in the coil 101 when wound in this configuration.

FIGURE 9 (exploded view) shows a convenient possible method of manufacture of a core with a winding. Two layers of amorphous metal 102, 102' have a printed-circuit coil 101 sandwiched between them. The flux (not shown but travelling horizontally across this Figure) will travel horizontally through the left hand layer 102, then vertically through the printed circuit coil 101, and then horizontally through the right hand layer 102'. This embodiment is easy to manufacture and can be very thin.

FIGURE 10a shows how magnetic field lines 101 entering the core 102 from the ends and sides result in the field strength within the core 102 being a maximum at its centre. As a result, more material is required in the centre to avoid saturation. FIGURE 10b shows a way to fold a single triangular piece of amorphous metal 200 in a concertina-like manner along fold lines 210 to achieve this effect. FIGURE 10c shows the resulting core 102 from above, FIGURE 10d a view from the end of the partially-folded assembly, and FIGURE 10e a view from the side. It will be appreciated that a similar core 102 may be constructed by cutting the sheet of material 200 into strips along the fold lines 210 of Figure 10b and then laminating the strips on top of each other to arrive at a core 102 similar to that of Figures 10c and 10e. Indeed, an equivalent core 102 may be constructed simply by laminating successively shorter strips of amorphous magnetic material on top of each other, the strips not necessarily having been cut from a triangular sheet.

FIGURES 11a to 11c show three possible arrangements of laminar metal core 102 used within a battery cell 140, capable of inductively receiving power for recharging the battery cell 140. In Figure 11a, the core 102 is wrapped completely around the cell 140 as a cylinder, with a coil 101 being wound or wrapped around the core 102. In Figure 11b, a smaller core 102 is placed on or near an outer surface of the cell 140 and bent into a curve to conform with the curvature of the cell 140, again with a coil 101 being wound or wrapped around the core 102 (but not around the cell 140 itself, as in Figure 11a). Figure 11c shows a core 102 placed inside the cell 140 and wound or wrapped with a coil 101.

FIGURE 12 shows an external unit in the form of a charging pad 150 generating a substantially horizontal electromagnetic field 1 and a cell 140 containing a laminar core component 102 in the manner of Figure 11. If the cell 140 is placed on or in proximity to the unit 150, the field 1 generated by the unit 150 will couple to the laminar core 102 and can thus charge the battery 140. The important point to note is that because the cell 140 is relatively thin, and the field 1 is flowing along its length, the cell 140 will receive power regardless of its axial rotation rA. This is particularly

useful if the cell 140 has been placed in a random orientation into a battery holder within a portable electronic device (not shown), as is often the case.

FIGURE 13 shows one possible implementation of the present invention in which an externally-applied alternating magnetic field 1 flows into the ends of an amorphous metal core 102. The core is composed of 6 pieces of Metglas® 2714A cobalt-based amorphous metal tape, each 50mm x 25mm x 0.018mm, stacked on top of one another into a thin laminar composite core. The number of pieces is chosen to prevent saturation at the operational field strength which oscillates at 40kHz.

Around this core 102 are wrapped 40 turns of 0.25 mm diameter enamelled copper wire, creating a flat-wound coil 101. The number of turns is chosen in order to develop sufficient voltage for the subsequent circuit. The gauge is chosen in order to keep resistive (heating) losses low. A thin layer of protective material (e.g. paper or plastic), not shown, may be interposed between the core and the windings to protect the enamel insulation of the windings. The thickness of this entire magnetic assembly is less than 1mm.

Optionally, capacitor C1 (150nF) increases the Q of the magnetic assembly to a moderate value, allowing more energy to be captured from the external magnetic field 1. Raising the Q also tunes the assembly, and increases the dissipation in the coil 101, but this low value still leaves the assembly relatively efficient and insensitive to variations in the frequency of the externally-applied magnetic field 1. An alternative circuit topology would be a capacitor in series with the load (series-resonant) rather than the parallel-resonant topology shown here. However this causes a large current to flow through the capacitor and large voltages to be developed across it, causing it to become hot and possibly break down due to excessive voltage.

Optionally, the power collected by the above magnetic assembly can flow directly into a component capable of utilizing AC power directly, for example resistor R1, which is a heating coil, providing heat to a cup-warming device (not shown) for example. However more typically the power is converted to DC for use by

conventional electric or electronic circuits.

In this regard, the coil 101 is centre-tapped and current flows from it into a full-wave rectifier consisting of power diodes D1, D2, and thence into smoothing capacitor C2 of 1uF which smoothes the 40kHz ripple to an acceptable level, providing a DC voltage of approximately 5V.

In some applications, the external alternating magnetic field 1 may, in addition to its alternation at 40kHz, also rotate approximately in the plane of the core 102, perhaps at some lower frequency. In this case the smoothing capacitor C2 must be of sufficient capacity to ride out the dips in voltage caused when the external field 1 is at 90 degrees to the coil 101 and thus induces no current therein.

An optional 3-terminal regulator Q1 may be provided to convert the smoothed DC into regulated DC.

The circuit then connects to the device 120 in/to which it is fitted, providing the device 120 with power. For example, the entire circuit above may be fitted inside the back casing of a mobile telephone and connected to its power/charging circuits, delivering 2W to charge at the same rate as a conventional plug-in charger.

Optionally, the device 120 might be a rechargeable cell, in which case regulator Q1 might be a charge-controller integrated circuit capable of managing fast-charging, trickle charging and the like.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A magnetic core component for transferring power by induction to or from a device, the magnetic core component including a thin sheet of metal in a substantially amorphous or non-annealed state and being provided with means for transferring induced electrical power from the core component to a device.

2. A core component as claimed in claim 1, wherein the metal is at least 70% amorphous or non-annealed.

3. A core component as claimed in claim 1, wherein the metal is at least 90% amorphous or non-annealed.

4. A core component as claimed in any preceding claim, wherein the sheet of metal has a thickness of 0.5mm or less.

5. A core component as claimed in any one of claims 1 to 3, wherein the sheet of metal has a thickness of 0.1mm or less.

6. A core component as claimed in any preceding claim, wherein the sheet of metal is flexible.

7. A core component as claimed in any preceding claim, wherein the sheet of metal is a multilayered sheet.

8. A core component as claimed in claim 7, wherein the multilayered sheet comprises layers of two or more different metals.

9. A core component as claimed in any preceding claim, wherein the sheet of metal is provided with a coil of conductive wire or tape or a flexible printed circuit.

10. A core component as claimed in claim 9, wherein the sheet of metal has a

longer and a shorter planar dimension, and wherein the coil of conductive wire or tape or the flexible printed circuit is wrapped or wound around the shorter planar dimension.

11. A core component as claimed in claim 9 or 10, wherein the coil or the flexible printed circuit is tuned to a higher quality factor (Q) with a capacitor connected in series or in parallel.

12. A core component as claimed in claim 11 depending ultimately from claim 7, wherein the capacitor is formed by separate metal layers of the multilayer sheet, separated by layers of a dielectric material.

13. A core component as claimed in claim 9 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a half- or full-wave rectifier.

14. A core component as claimed in claim 9 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a smoothing capacitor.

15. A core component as claimed in claim 9 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a regulator or a battery charge-controller.

16. A core component as claimed in any preceding claim, wherein the core component includes at least two sheets of metal material laminated to each other about a coil.

17. A core component as claimed in any preceding claim, wherein the sheet of metal material is thicker in a central part thereof than at end parts thereof.

18. A core component as claimed in claim 17, wherein the sheet of metal material is formed by folding a larger sheet of metal material in a concertina-like manner.

19. A core component as claimed in claim 18, wherein the larger sheet of metal material is generally triangular.

20. A core component as claimed in claim 9 or claim 16 or any claim depending therefrom, wherein an additional coil or flexible printed circuit is provided in a configuration substantially orthogonal to the said coil or flexible printed circuit.

21. A device provided with a magnetic core component for receiving or transmitting power by electromagnetic induction, characterised in that the magnetic core component includes a thin sheet of metal in a substantially amorphous or non-annealed state.

22. A device as claimed in claim 21, wherein the metal is at least 70% amorphous or non-annealed.

23. A device as claimed in claim 21, wherein the metal is at least 90% amorphous or non-annealed.

24. A device as claimed in claim 22 or 23, wherein the sheet of metal has a thickness of 0.5mm or less.

25. A device as claimed in claim 22 or 23, wherein the sheet of metal has a thickness of 0.1mm or less.

26. A device as claimed in any one of claims 21 to 25, wherein the sheet of metal is flexible.

27. A device as claimed in any one of claims 21 to 27, wherein the sheet of metal is a multilayered sheet.

28. A device as claimed in claim 27, wherein the multilayered sheet comprises

layers of two or more different metals.

29. A device as claimed in any one of claims 21 to 28, wherein the sheet of metal is provided with a coil of conductive wire or tape or a flexible printed circuit.

30. A device as claimed in claim 29, wherein the sheet of metal has a longer and a shorter planar dimension, and wherein the coil of conductive wire or tape or the flexible printed circuit is wrapped or wound around the shorter planar dimension.

31. A device as claimed in claim 29 or 30, wherein the coil or the flexible printed circuit is tuned to a higher quality factor (Q) with a capacitor connected in series or in parallel.

32. A device as claimed in claim 31 depending ultimately from claim 27, wherein the capacitor is formed by separate metal layers of the multilayer sheet, separated by layers of a dielectric material.

33. A device as claimed in claim 29 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a half- or full-wave rectifier.

34. A device as claimed in claim 29 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a smoothing capacitor.

35. A device as claimed in claim 29 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a regulator or a battery charge-controller.

36. A device as claimed in any one of claims 21 to 35, wherein the core component includes at least two sheets of metal material laminated to each other about a coil.

37. A device as claimed in any one of claims 21 to 36, wherein the sheet of metal

material is thicker in a central part thereof than at end parts thereof.

38. A device as claimed in claim 37, wherein the sheet of metal material is formed by folding a larger sheet of metal material in a concertina-like manner.

39. A device as claimed in claim 38, wherein the larger sheet of metal material is generally triangular.

40. A device as claimed in claim 29 or claim 36 or any claim depending therefrom, wherein an additional coil or flexible printed circuit is provided in a configuration substantially orthogonal to the said coil or flexible printed circuit.

41. A device as claimed in any one of claims 21 to 40, wherein the sheet of metal material is at least partially wrapped around an axis of the device such that it couples with an electromagnetic field in any rotation about the axis.

42. A magnetic core component, substantially as hereinbefore described with reference to or as shown in Figures 4, 5a, 5b, 5c, 6b and 7 to 13 of the accompanying drawings.

43. A device provided with magnetic core component, substantially as hereinbefore described with reference to or as shown in Figures 4, 5a, 5b, 5c, 6b and 7 to 13 of the accompanying drawings.

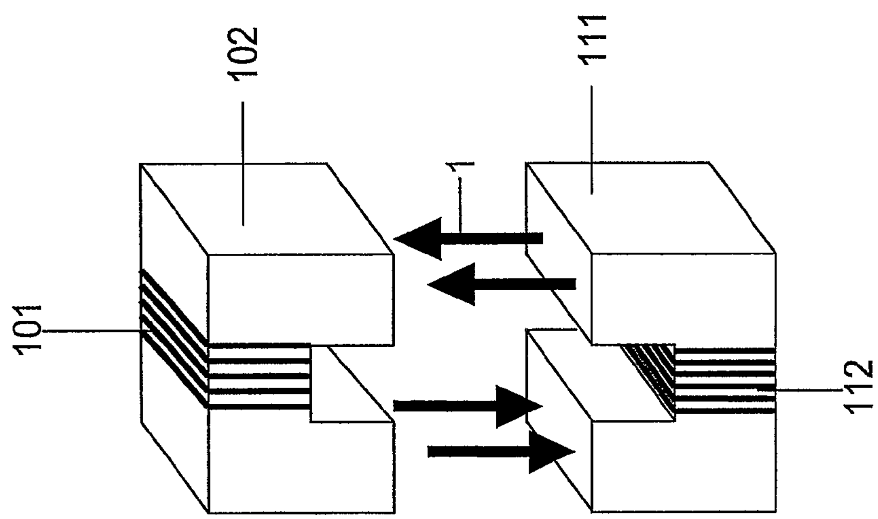

Figure 1
(Prior Art)

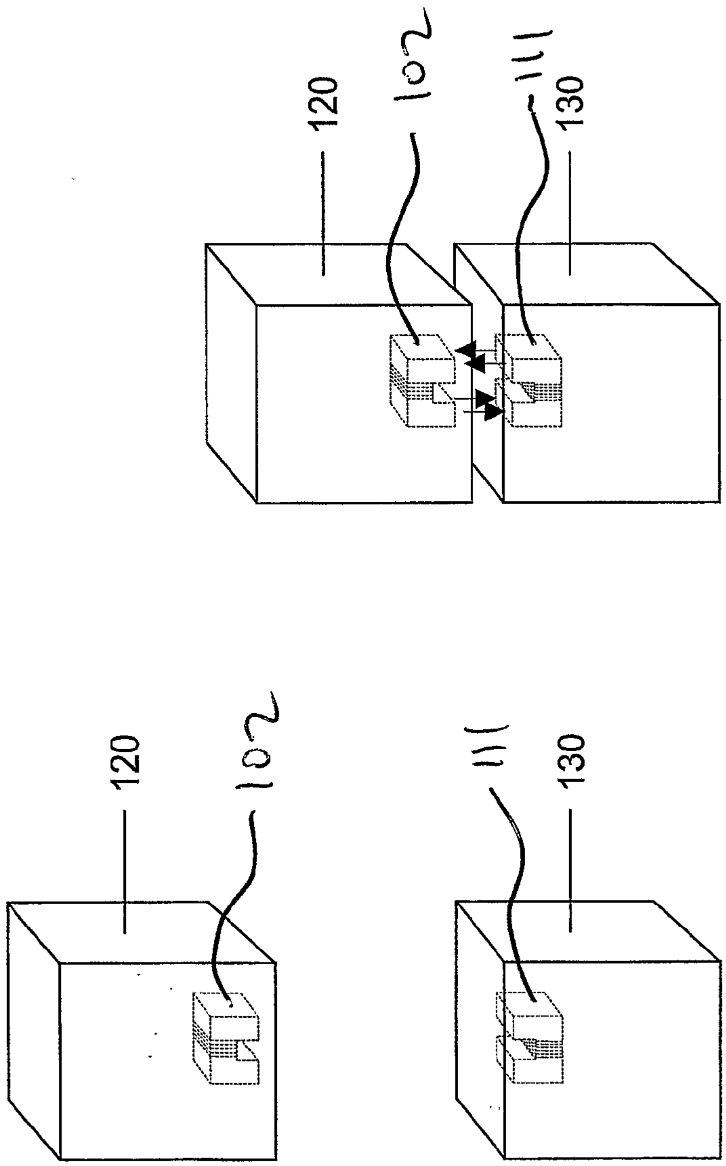

Figure 2
(Prior Art)

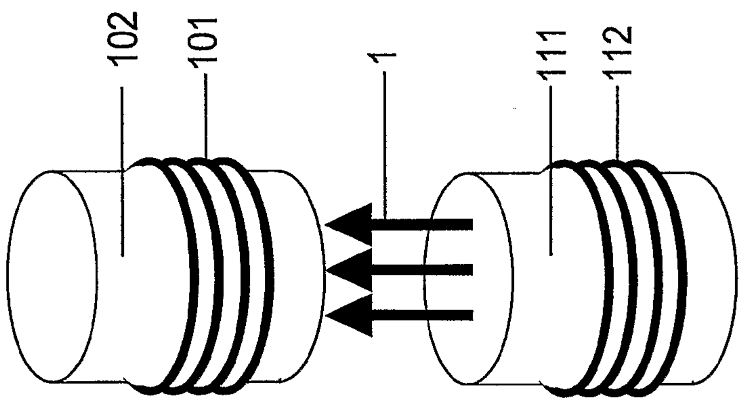

Figure 3
(Prior Art)

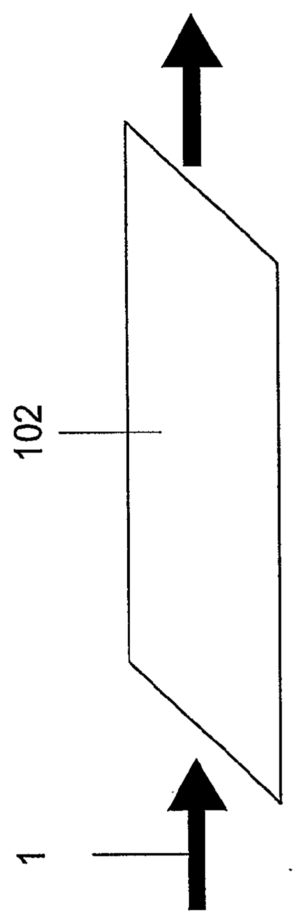

Figure 4a

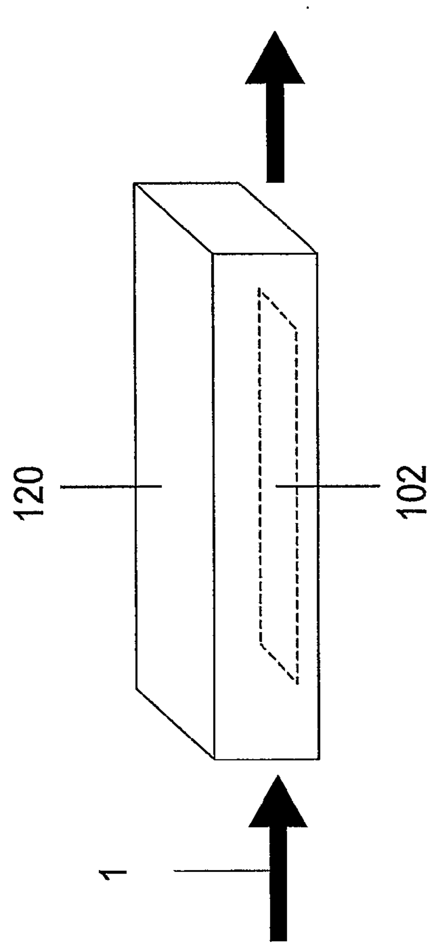

Figure 4b

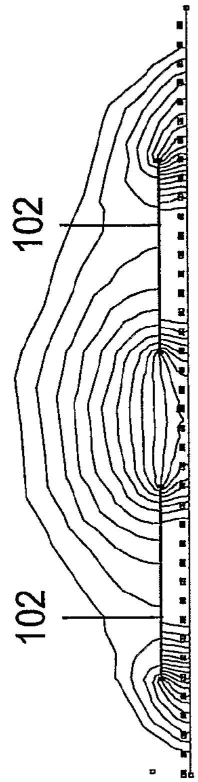

Figure 5c

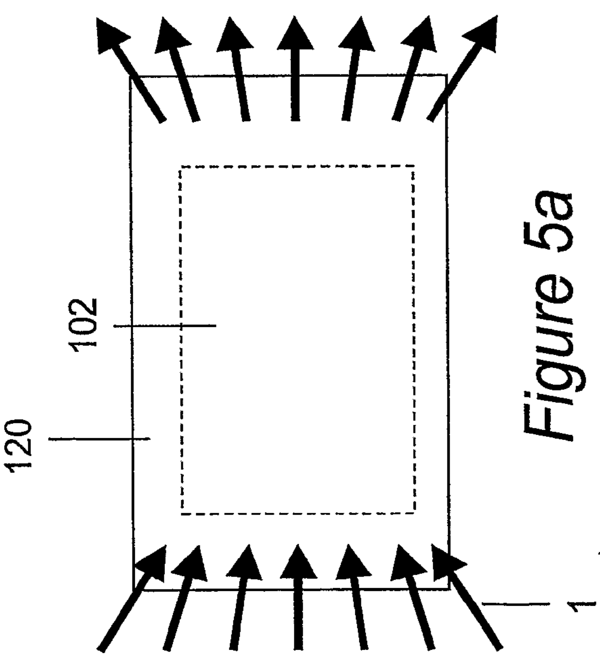

Figure 5a

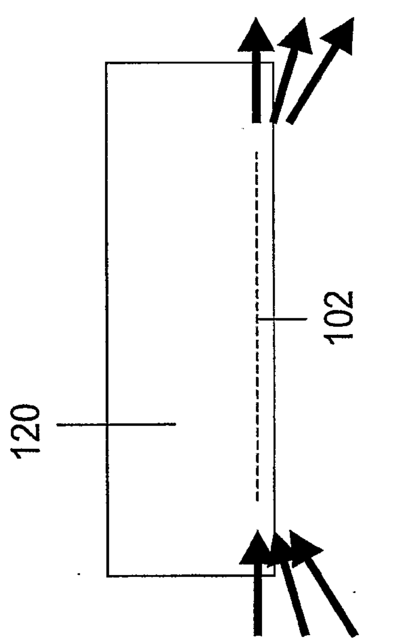

Figure 5b

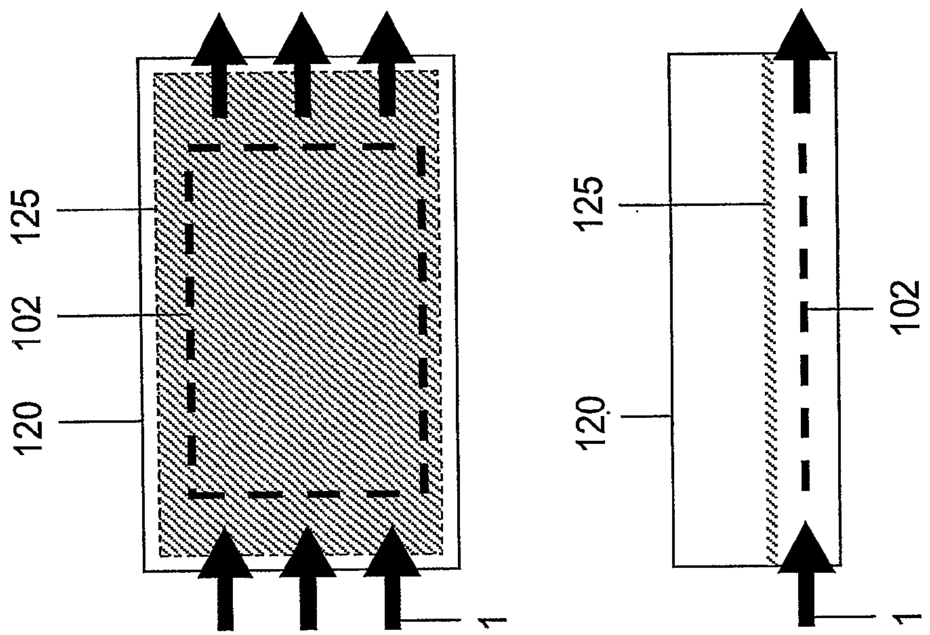

Figure 6b

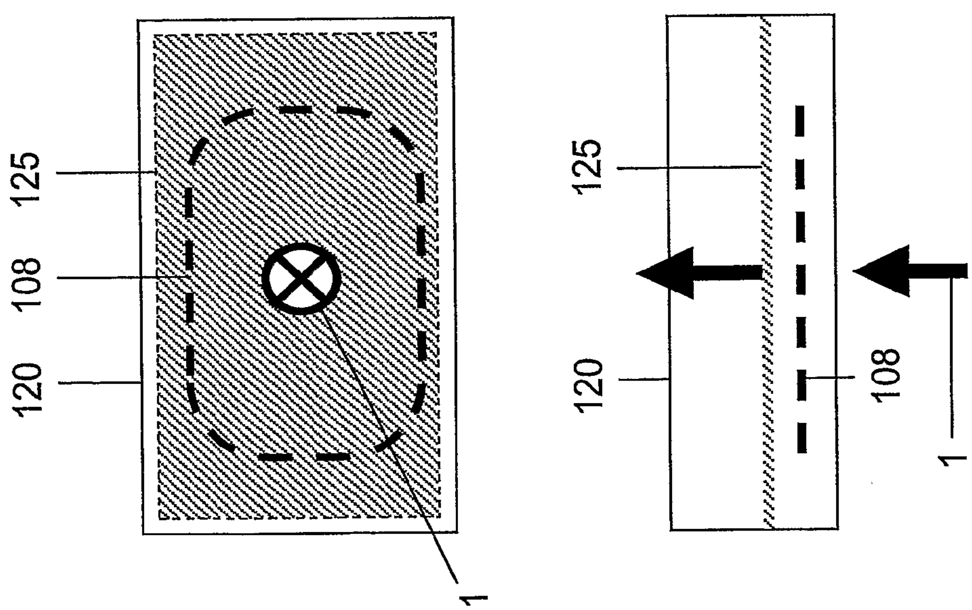

Figure 6a

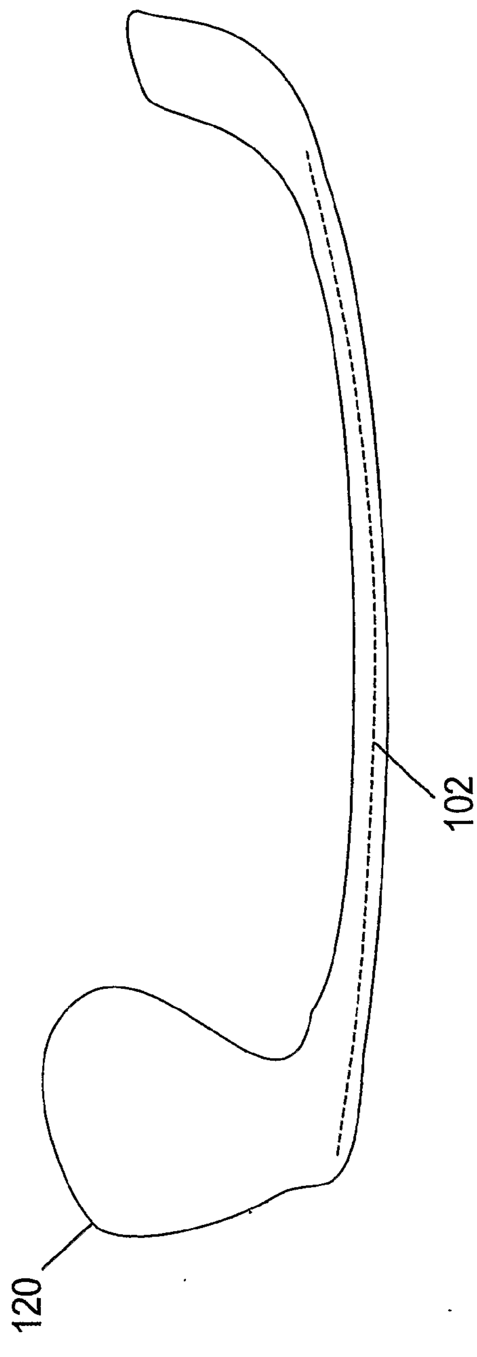

Figure 7

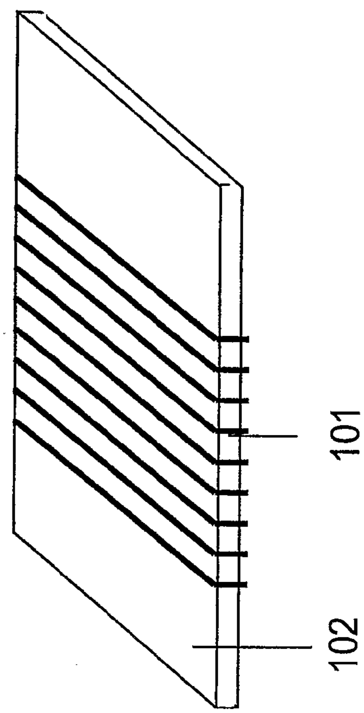

Figure 8

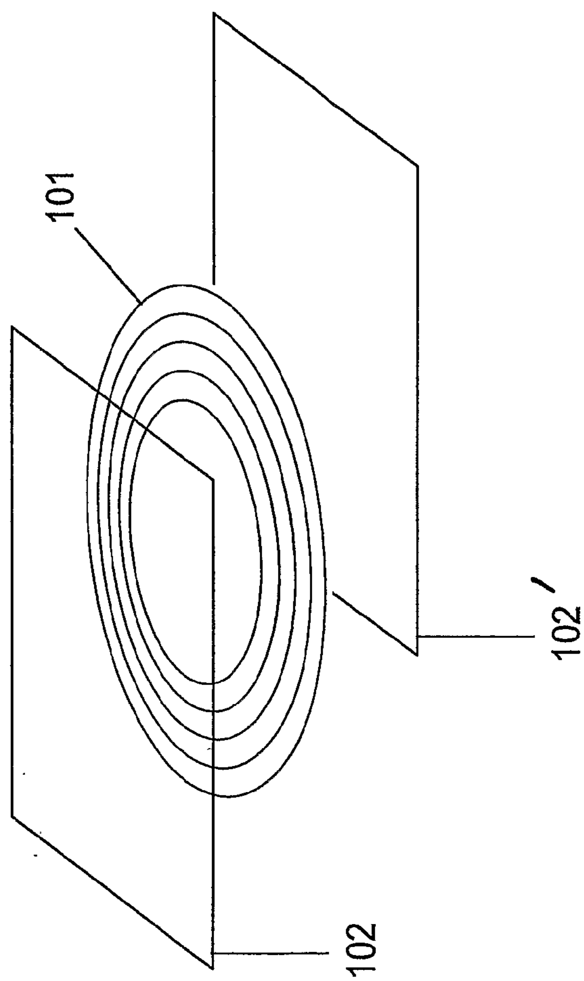

Figure 9
(exploded drawing)

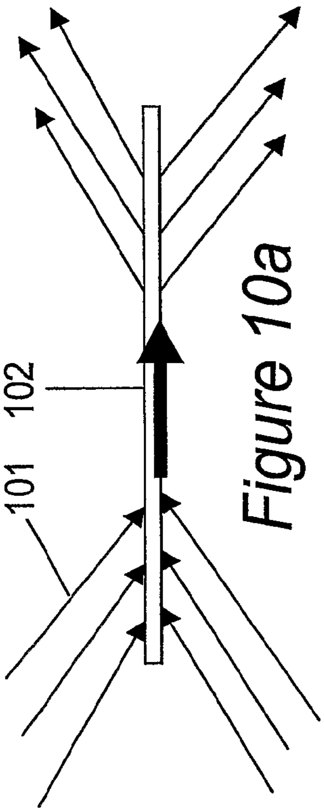

Figure 10a

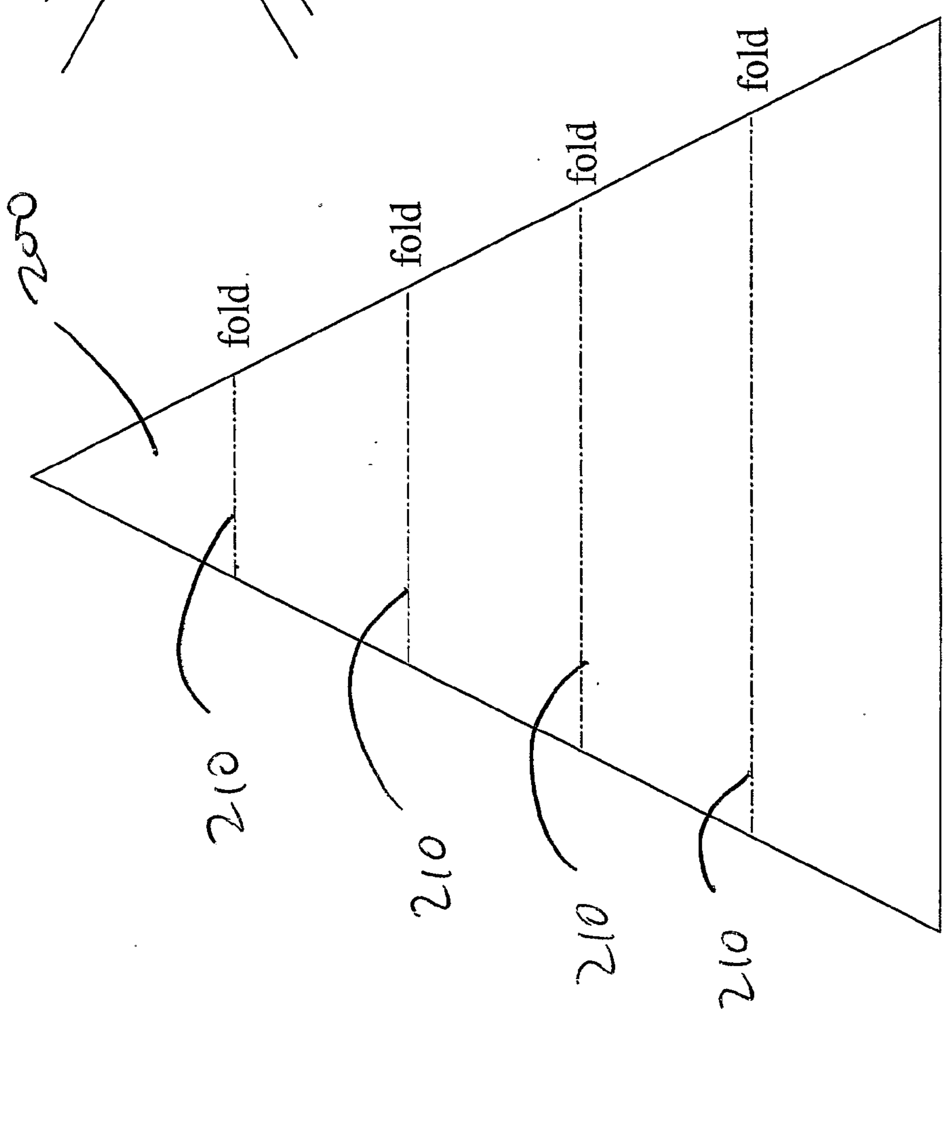

Figure 10b

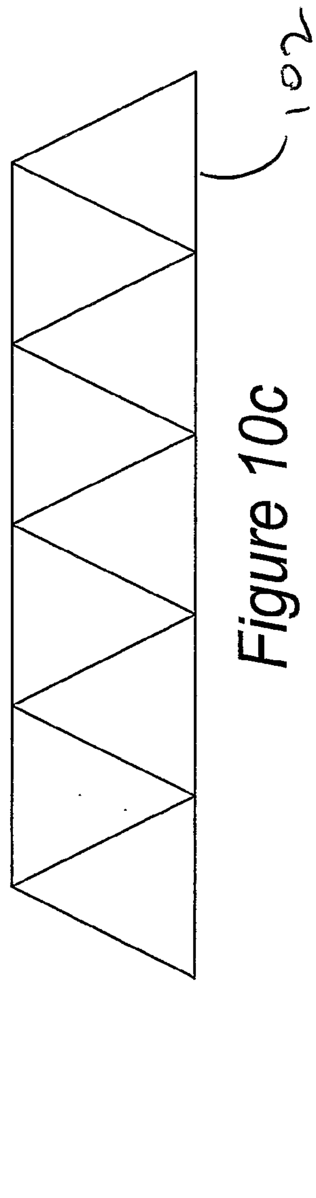

Figure 10c

Figure 10d

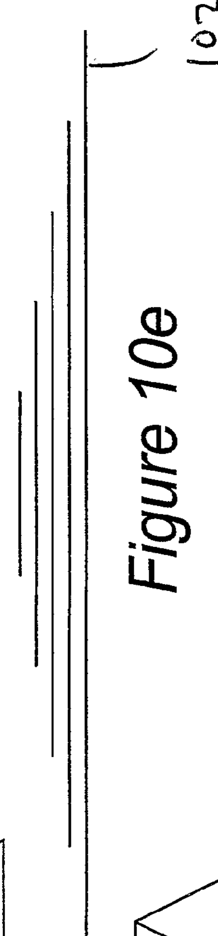

Figure 10e

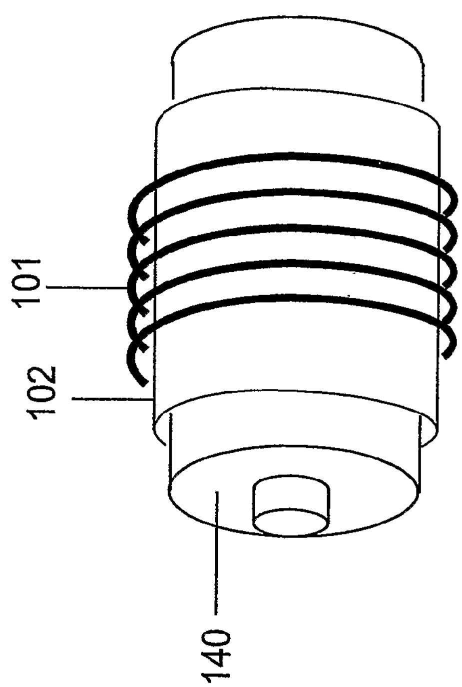

Figure 11a

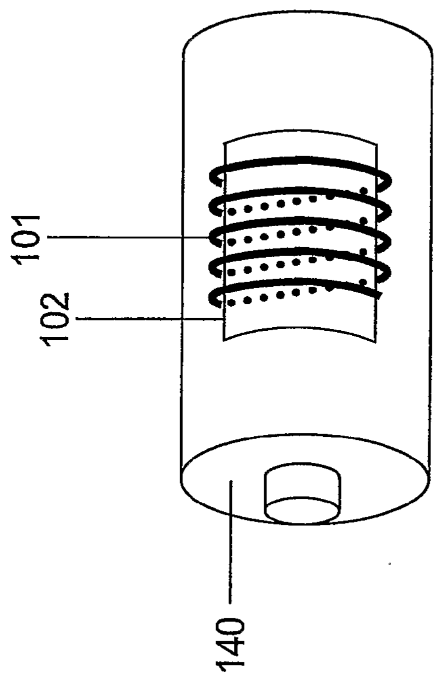

Figure 11b

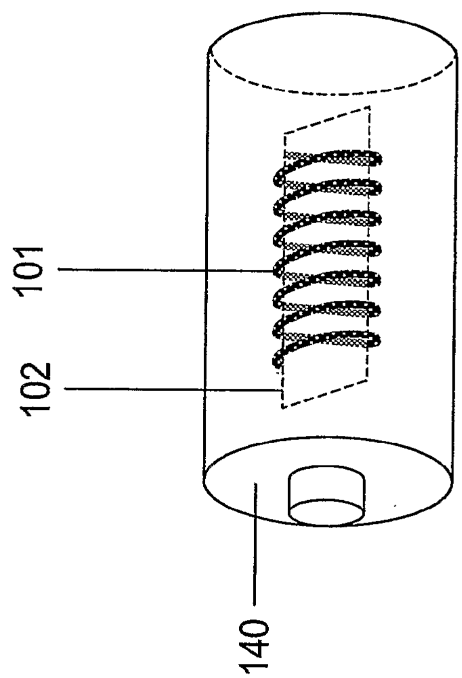

Figure 11c

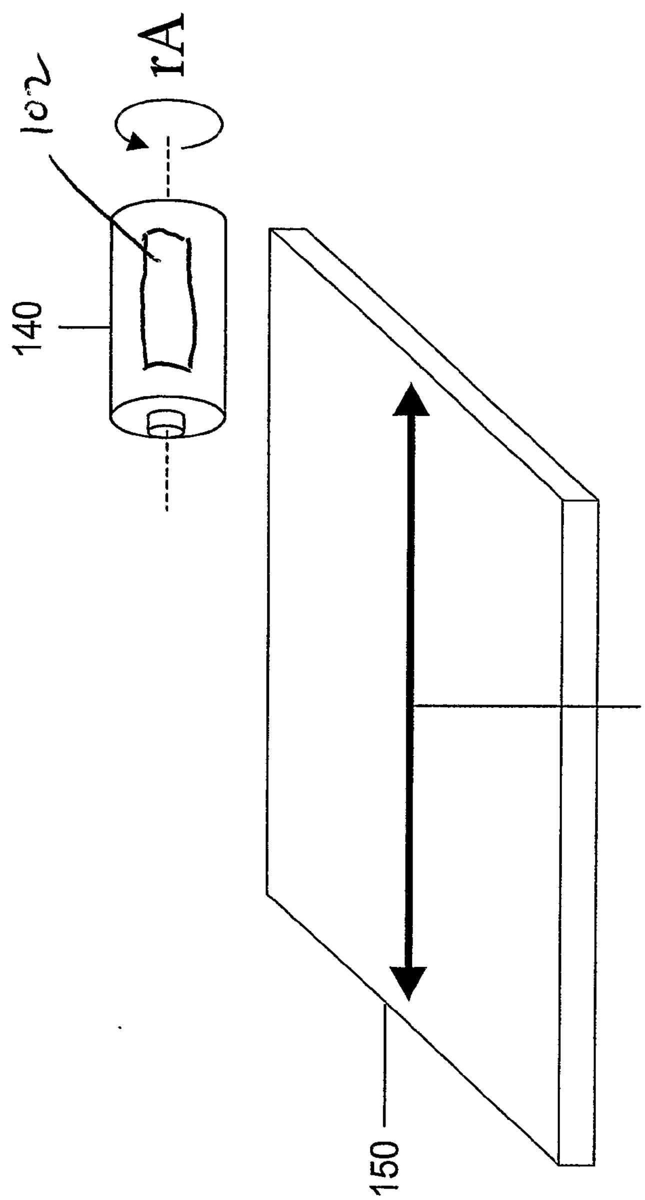

Figure 12

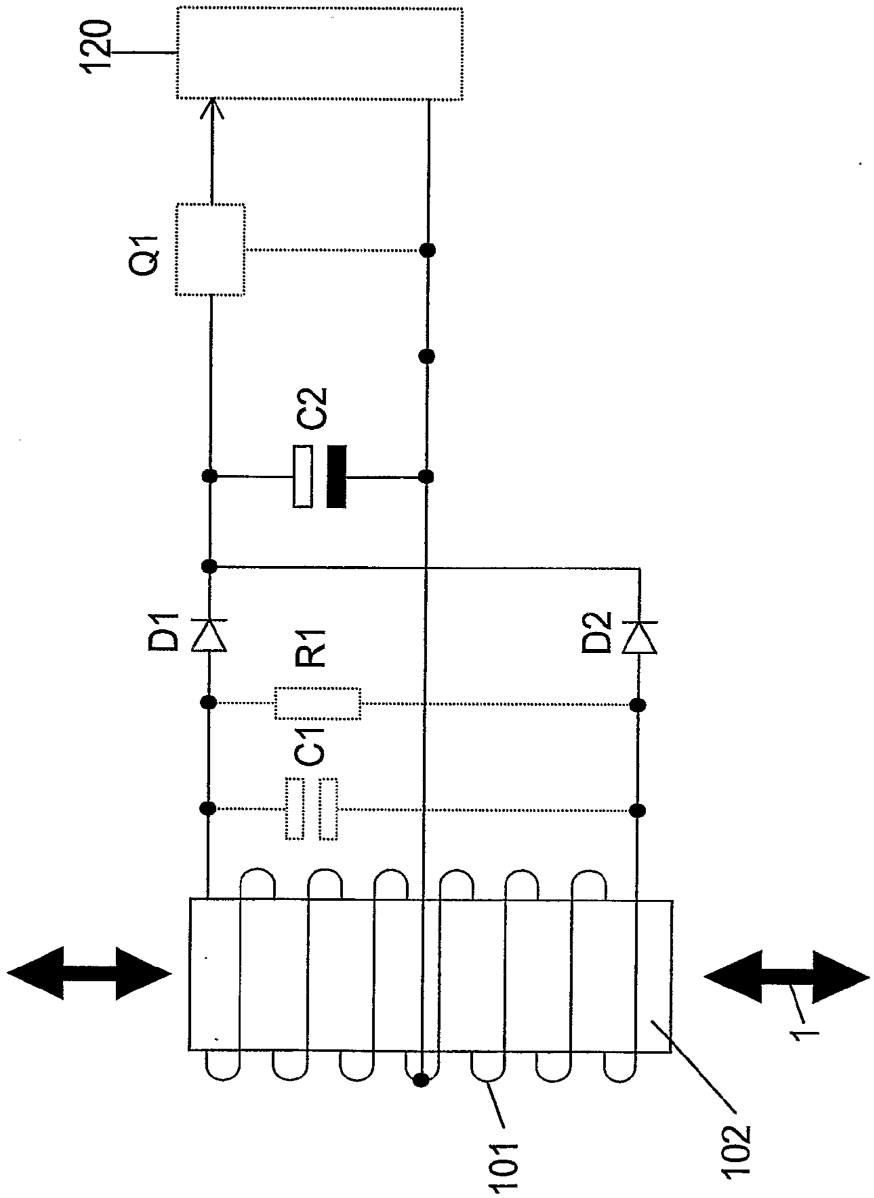

Figure 13

INTERNATIONAL SEARCH REPORT

Internat Application No
PCT/GB 03/02038

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01F41/02 H01F27/25 H02J7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01F H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 528 113 A (BOYS JOHN T ET AL) 18 June 1996 (1996-06-18) column 3, line 1-12; figure 2	1
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 14, 31 December 1998 (1998-12-31) & JP 10 241936 A (ALPS ELECTRIC CO LTD), 11 September 1998 (1998-09-11) abstract	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2003	04/09/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Durville, G

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 03/02038

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5528113	A	18-06-1996	AU	8006494	A	08-05-1995
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			DE	69432262	D1	17-04-2003
			EP	0727105	A1	21-08-1996
			JP	7170681	A	04-07-1995
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JP 10241936	A	11-09-1998	NONE			